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ABSTRACT

The cognitive learning processes of assimilation and accommodation are critically examined in this paper. A special focus is given to an analysis of the process of assimilation as it is proposed in Hugh Petrie's book, "The Dilemma of Enquiry and Learning." Initially, Piaget's biological metaphor of assimilation-accommodation is reviewed and then is followed by a discussion of a new metaphor drawn from the field of cybernetics. A control systems metaphor is described and compared to the process of assimilation as a special case of rule following. It is suggested that teachers and scholars use Petrie's model of accommodation to explain both of the learning processes, for in this model the learner continually tries to fit sensory inputs into an existing set of conceptual schemes. (ML)

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Robert E. Floden

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Abstract

Teachers are taught to think of student learning as complementary processes of assimilation and accommodation, but teachers (and scholars) find these concepts difficult to understand. Thus these concepts provide little guidance for decisions about curriculum and instruction. This paper critiques a philosophical analysis of assimilation as a feedback system, revealing central difficulties with this approach to Piaget's theory of learning. Teachers and scholars interested in understanding learning would be better off doing without the distinction between assimilation and accommodation, for the processes differ more in degree than in kind.

EXPLAINING LEARNING:
BIOLOGICAL AND CYBERNETIC METAPHORS

Robert E. Floden[1]

Recent psychological research has revived the Kantian notion that people do not observe the world directly; people must shape sensory information into mental frames or conceptual schemes before they can make sense of experience. The notion that people construct the world--rather than being passively impressed by it--underlies Piagetian theory, information-processing psychology, and research on artificial intelligence. Psychologists have departed from Kant by suggesting that these schemes are numerous and context-specific and that they change over time. The questions of how people use conceptual schemes to make sense of their environment, and of how those schemes change, are crucial to education, because they are questions about fundamental learning processes.

Many analyses of active cognitive learning use Piaget's complementary concepts of assimilation and accommodation. Assimilation is defined as the process by which people use existing conceptual schemes to make sense of sensory inputs. As Piaget (1971) says: "We use the term assimilation in the wide sense of integration into previous structures" (p. 4). Accommodation is the process by which people change their conceptual schemes so that they can assimilate anomalous stimuli or reinterpret remembered events. Together these processes explain learning: assimilation explains how people learn about things that fit familiar schemes; accommodation explains how people can learn new schemes.

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This pair of concepts seems attractive but mysterious. The processes they refer to seem distinct yet somehow inseparable. Their symmetry seems almost too neat. They appear to be twin processes of learning, yet sometimes only accommodation seems tied to learning, for assimilation leads, not to a change in the individual, but to an interpretation of the environment. One fundamental question is whether two processes are at work here or two aspects of a single process. Is there a basic learning process, with different outcomes in different situations, or are there two processes involving different mechanisms? The biological metaphors of assimilation and accommodation suggest distinctness, but does the metaphor mislead?

Psychology has no definitive answers to these important questions. But progress in understanding learning can be made by appraising specific attempts to make sense of Piaget's biological metaphor. Hugh Petrie's book, *The Dilemma of Enquiry and Learning* (1981), contains a well-elaborated proposal for making sense of the metaphor in the context of education. The book covers many topics, but centrally features analyses of these two types of learning.

I will concentrate on Petrie's unusual analysis of assimilation. Because Petrie wishes to address the acquisition and use of *knowledge*, the interpretations made through assimilation must be reasonable not arbitrary. Petrie attempts to introduce rationality by basing his model on rule following. To avoid the standard objection that this analysis provides teleological, rather than causal, explanations of behavior, Petrie represents rule following, and hence assimilation, using a new metaphor, the metaphor of a cybernetic control system.

This paper critically examines Petrie's proposal, asking if the analysis is adequate and if it provides a way of understanding assimilation as a process distinct from accommodation. I will argue that the control systems

metaphor, though general enough to cover a wide variety of processes, fails to capture central features of the process Petrie hopes to explain--assimilation of familiar situations and behaviors into an existing network of conceptual schemes. However, Petrie's model for accommodation--the process by which conceptual schemes are revised--shows promise as a model for assimilation as well.

The Biological Metaphor

When instructors in psychological foundations or school learning courses tell their students that learning is composed of assimilation and accommodation, students sometimes complain that they have difficulty understanding exactly what these terms mean. The course texts are seldom clear, and a return to Piaget's publications seldom yields instant enlightenment. Part of the problem may lie with Piaget's prose, but a more basic problem is that the terms are metaphors that have not been elaborated. Piaget has taken the concepts from biology, reflecting both his own biological research and his broad contention that the growth of human knowledge is an extension of evolutionary processes. As with most metaphors, it is difficult to separate learning that resembles assimilation and accommodation from the irrelevant features or points of outright contradiction.

According to biologists, organisms adapt to their environments in two ways. They absorb raw materials from the environment and transform them into organic substances used for producing energy or building new cells. A child eats a hamburger and then transforms it into the fats, sugars, and proteins needed for movement and growth. Through this process of assimilation the hamburger is transformed into the organic compounds suitable for the body's current needs.

Important aspects of the environment that do not fit into that current form may produce changes in the organism itself such that the organism accommodates to the environment. Thus assimilation is the process by which an organism changes parts of the environment so that those parts fit into existing organic structures such as fat and muscle. Accommodation is the process by which the organism modifies its organic structures so that the environment can be tolerated and even assimilated.

Piaget and Petrie use this pair of biological concepts to explain learning. People do not literally ingest stimuli, but sensory information can be either transformed so that it fits into existing mental schemes (we can call them mental structures if we do not take the word "structures" too seriously), or the mental schemes can be modified so that recalcitrant information can be tolerated or assimilated. In school settings, for example, children are stimulated by patterns of black (or purple) ink on pieces of paper and by patterns of vibrations in the air. At a basic level, these are assimilated as printed letters and words and as spoken language. At a more sophisticated level, these words are assimilated into existing patterns of knowledge. When the algebra teacher begins a story problem saying, "A river steamer . . .," the students already begin to transform the teacher's talk into the familiar form of a rate-time-distance problem. If the students cannot make any adequate transformation of the written or spoken patterns, they must add additional mental schemes or modify old ones.

One can find support for using the biological metaphor of assimilation to explain learning in contemporary cognitive psychology (e.g., Anderson, 1984), which has adopted a theory of mental operations emphasizing the role that current beliefs have on the interpretation of sensory stimulation. For the most part, only those stimuli that fit into an existing mental structure will

be part of the person's understanding of the environment. Other stimuli are ignored and forgotten. The similarity to assimilation is obvious. Sensory stimuli ("information" is really too strong a term--it connotes comprehension) are "ingested," then transformed (by ignoring most of them and perhaps even adding or modifying some) so that they fit into the existing set of beliefs about the world.

The Control Systems Metaphor

The biological metaphor is suggestive, but questions remain about how the suggestions will play out in the context of school learning. Petrie recognizes this, and considers two questions important for the educational context, questions that biology addresses through studies of biochemical processes.

1. How is it that the proper scheme is selected (or one of the proper schemes, when several may do)?
2. How is it, then, that the sensory stimuli are transformed so that they fit into this scheme?

Though cognitive psychology has endorsed the notion that conceptual schemes exist and affect learning, little has been done to explain the operation of the process. It is such an explanation (or at least the initial steps toward an explanation) that Petrie hopes to provide by turning for a new metaphor of learning from biology to cybernetics.

Though Petrie draws explicitly on a recent exposition of control systems theory in a psychological context (Powers, 1973), the idea of using a feedback loop to regulate system operation has been around for some time, finding prominent 20th-century expression in the writings of Norbert Wiener (1948). A thermostatically controlled heating system is a good example of a cybernetic control system. Air temperature is continually monitored by the bimetal strip in a thermostat. Whenever the temperature falls below the temperature

setting, the thermostat sends a signal to the furnace causing it to begin heating the air. When the temperature reaches the setting again, the thermostat stops sending this signal and the furnace shuts off. Thus the system maintains a reasonably constant temperature throughout the winter.

The central concept of control systems theory is that of a sensing and comparing mechanism that initiates actions to restore the system to some standard. The sensor monitors an input signal determined by some aspect of the system or its environment. In my example the thermostat is the sensor, which monitors the temperature in its immediate vicinity. The sensor frequently (perhaps continually) compares this input signal to the standard. In the example the thermostat compares the actual temperature to the temperature that has been set. Whenever the monitored signal deviates from the standard, the sensor activates a mechanism capable of affecting the environment, presumably in a way likely to push the input signal back toward the standard. The thermostat turns on the furnace, which heats the building, causing the temperature around the thermostat to move closer to the set temperature.

Petrie compares this model to assimilation. Since assimilation is not a process with some reference standard, this seems strange. The problem for assimilation is not how a system can be kept stable, but how information can be appropriately interpreted. To see the attraction of the control systems model, one must understand that Petrie (1981) sees the problem of explaining assimilation as closely related to that of explaining rule-following behavior. Indeed, in the chapter entitled "Assimilation," he concentrates largely on a discussion of rule following. The following is his two-sentence description of the purpose of that chapter:

> The task for this chapter is to explain how experiencing with our conceptual schemes occurs. I need to account for how stable conceptual structures impose a similarity and continuity on the diversity of sensory stimulation and behavioral activity actually observed. (p. 74)

Later in the chapter introduction he adds two other tasks: "how to account for minor variants within a given conceptual scheme" and "showing how routine human action can be seen as reasonable, at least from the agent's point of view" (p. 75).

Though Petrie's introduction assigns importance to all three tasks, the last task is given virtually all the attention. Human action is seen as reasonable by seeing it as rule following. Hence the extended discussion of rules, ending with control systems as the metaphor for human rule following. Control systems theory is more evidently appealing as a representation of rule following than as a representation of assimilation. The ideal standard is the rule being followed. The sensor checks whether or not the rule is being followed and starts corrective action whenever deviations occur.

Once the task of explaining assimilation is equated with explaining how people follow rules, Petrie's discussion is no more problematic than the mainstream of philosophical literature on rule following. A control system may well be a schematic representation on what it means to follow a rule. What is more important for this paper, however, is to examine whether the initial step incorporating assimilation as a special case of rule following is warranted. How sensible is it to see assimilation as following a rule? Assuming Petrie's explanation of rule following is adequate, has assimilation been explained?

What Rule Do You Follow?

You walk into a room and immediately you see the room as a classroom. You see the person standing close to one wall as the professor. You see that wall as the "front" of the room. You see the other people seated in the room as students. Those looking generally toward the front you see as "paying attention." Those looking in the direction of the window you see as

"inattentive." How does this happen? How is it that most college-educated Americans would see the room in the same way?

Because seeing the room in this way is an example of assimilation, an adequate explanation of assimilation must answer those two questions. Rule following is at most one aspect of what is going on. If the control systems metaphor is to explain assimilation, it should indicate how the sensory inputs are given the meaning, "college classroom," and why they are given that meaning rather than "grocery store" or "concert hall."

Petrie would claim that the conceptual scheme, "classroom," is the rule operating in this case. What then are the sensor and effector functions? Presumably some mental control process operates as sensor, checking the visual and auditory stimuli to see if they fit the scheme. When stimuli not fitting the stimuli are found, the effector function causes some other part of the brain to ignore them. So the control mechanism checks to see if stimuli fit the conceptual schemes and ignores them if they do not.

But this merely redescribes the data, with the addition of a postulated control process. We already knew that the person entering the room attended only to stimuli that fit the classroom pattern. The question is how that selective attention comes about. Saying that it occurs through the operation of a checking mechanism and an inattention mechanism adds words but not understanding.

What is more, Petrie himself denies that the control system does as much as this. He stresses that the control system does not control perceptions but rather changes behavior. The deviation from the reference standard triggers a process in which the person acts on the environment in some way that typically tends to alter the inputs so that they are closer to the standard. In the example, that might be putting the chairs into neat rows or providing the

chalk and eraser for the blackboard--things that would make this room more like the stereotypical college classroom. But if the control system does not change perceptions, it does not explain assimilation. What is to be explained is how perception is governed so as to fit the conceptual scheme. In this case, the person walking into the room does nothing to change the environment. The incoming stimuli are selected and modified to fit the preconception, but the stimuli themselves are not altered until the person changes the focus of attention to other stimuli that are in turn assimilated to existing conceptual schemes.

The control systems model is suited to situations in which a standard procedure will return the environment to normal. It is less applicable when different things might be done and the person must select from among them. A large problem is how to explain the selection of the scheme appropriate to a given situation. The model assumes the existence of a reference signal. But how is a reference signal *appropriate* to the current situation identified?

Petrie suggests that the true model of assimilation will be a complex *hierarchy* of control systems. But adding control systems within control systems adds complexity without adding explanatory power. What sort of reference signal could possibly drive the process of selecting a scheme? Even if there were such a reference, the model faces the same difficulty as before. Petrie claims that the system controls behavior not perception. But changing conceptual schemes is an action on perception not on behavior.

Control systems do less than Petrie would like them to. First, the situation must be perceived in terms of the rule. In a human situation with many reference signals, not all of which are controlled at the same time, the problem of deciding if this is a situation that fits the rule is transformed into

a problem of deciding which reference signal should get priority. Hence the problem doesn't go away, it just gets shifted.

Petrie thinks old solutions do not explain how novel situations can be dealt with, but control systems cannot explain how novel situations can be dealt with unless the standard effector function moves things in the right direction. Petrie begs the question by saying that the function will work if the system is at all adapted to the general conditions--ruling out interestingly novel situations.

Petrie links control systems theory to education by claiming it is the antidote to an overemphasis on behaviors (i.e., on outputs). Educational goals should be stated in terms of internal processes rather than outputs. The attainment of these processes can be tested by introducing discrepancies and seeing what happens. Whereas Petrie tries to make complex knowledge the reference signal, having complex knowledge is not the same as having a goal. It is true that testing for the existence of complex knowledge requires inferences, not mere existence of outputs. However, this is a general point about testing for the existence of unobservables, one that does not require any commitment to control theory, mental structures, or, for that matter, assimilation and accommodation.

Petrie tries to support his case for the control systems model by exploring examples of inference from tests and functions of schooling. In both cases, he points out that the control systems model suggests a way of determining the internal structure of a system, namely, observing the system under a variety of conditions and seeing if the system acts to attempt to return the environment to fit some rule. In the case of the functions of schooling, one can observe schools under different social and cultural situations and see

if the system acts to change schools and society to fit some hypothesized standard (e.g., the existence of a stable class system).

These examples show that the control systems model can be used to examine a wide variety of educationally important phenomena. They do not, however, show that the model has any application to the understanding of learning. Petrie has tried to elaborate Piaget's biological metaphor with a new metaphor. But rather than providing a more detailed picture, the clarity gained by the new metaphor shows its inapplicability to school learning.

Accommodation As a Model for Assimilation

A better model for the process of selecting appropriate conceptual schemes and interpreting stimuli and behaviors in terms of the schemes selected may actually be a version of the model Petrie proposes for accommodation. In this model, the selection of an appropriate scheme is compared to a scientist's selection of an appropriate theory. First, candidate conceptual schemes are brought forward as hypotheses. For each conceptual scheme, some selection of stimuli is made, limited to the components of the conceptual scheme. Stimuli that are not relevant are put aside; those that seem relevant but do not fit the theory are noted as counterevidence.

Scientists judge whether the amount of information that fits the theory is large enough to permit ignoring discrepant information, at least provisionally. They make additional checks on the conceptual schemes by taking actions that should lead to predictable results if the scheme is appropriate. A number of conceptual schemes may be tried before an adequate one is found. In cases where no scheme is adequate, accommodation--creation of novel conceptual schemes--may be necessary.

This model of theory selection provides answers to the two questions that a model of assimilation should address. The proper scheme should be chosen by

bringing forward candidate schemes and seeing how well they fit the inputs. This involves a comparison to some standard of fit, but, unlike the control systems model, the effect of failure to meet the standard is selection of a new scheme, not an attempt to change the environment. The inputs are transformed by ignoring those that do not fit the selected scheme, putting in those that do fit into the scheme and possibly using the scheme to "flesh out" the interpretation or to guide a search for additional information.

Of course this explanation is incomplete, but it is a step in the direction of fuller explanation. By taking the reference standard as a given, the control systems model provides no explanation of how schemes are selected. Furthermore, it does not explain how stimuli are transformed, since the model explains change in behavior, not in interpretation.

On Mixed Metaphors

The powers of metaphors are well known; so are their limitations. Metaphors stimulate the imagination and ease understanding; but one must be careful not to think that the utility of one part of a metaphor carries over to all its other aspects. Though the biological processes of assimilation and accommodation may resemble the psychological processes of learning, separate biological processes need not require separate learning processes. Perhaps even more care needs to be taken in mixing metaphors. A feedback loop is a powerful and general metaphor, but things can get confusing when feedback is a metaphor for eating and digestion is a metaphor for making mental sense of a new situation. Moreover, the general power of a metaphor does not preclude the necessity for checking its application in a specific situation.

The control systems model shows how a variety of behaviors have unity as attempts to control a single input, but the model does not show how assimilation reasonably imposes similarity on incoming stimulation. The model assumes

stimulation will be compared to some reference signal; it does not show how the particular comparison signal is *chosen*. Furthermore, the model is more appropriate for purposeful action than for assimilation. Wishes, motives, and intentions are more plausible reference signals than are conceptual schemes. The model controls perception through action that changes incoming stimuli; assimilation must explain how perceptions are constructed out of present stimulations.

Rather than using this separate model to explain assimilation, teachers and scholars interested in the assimilation-accommodation model of learning would be better off trying to use a single model--the model Petrie proposes to explain accommodation--to explain both processes. In this model, the learner is continually trying to fit sensory inputs into an existing set of conceptual schemes. The first strategy for doing so is to search through the current set of schemes, trying to find ones which the inputs will fit into, perhaps with some selective discarding and distorting of inputs. If none can be found, or the amount of discarding and distorting is excessive, then novel schemes are created and subjected to the same tests as existing schemes. (A similar suggestion is made in Block, 1982.)

Perhaps that process has more than one part--searching for promising schemes, creating novel schemes, and checking for fit (within some permissible limits of omission and distortion). All of these parts, however, fall under Petrie's description of accommodation. Recognizing that does not, unfortunately, provide a complete and rational explanation of learning. It does, however, allow theorists to discard the control systems metaphor in their search for a model of learning. Things are complicated enough without a hierarchy of control systems that bypass questions central to understanding

learning. As the theory suggests, models that do not fit the phenomena should be discarded.

In general, the shifts in metaphorical language do not necessarily help in understanding important questions such as how people learn. A flight into new metaphors can just as well import new difficulties having little to do with the phenomena to be explained, masking issues distinctive to those phenomena and putting scholars on the wrong scent. When education students have a hard time seeing what the concepts add to their understanding of learning, the fault lies with the concepts and not with the students.

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